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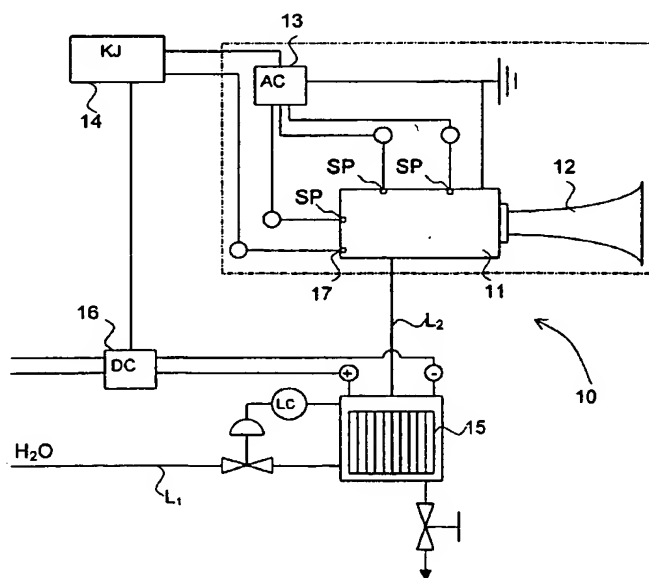
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- For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: APPARATUS AND METHOD FOR ACOUSTIC CLEANING



(57) Abstract: The invention concerns an apparatus for acoustic cleaning apparatus (10) includes a combustion chamber (11), an acoustic horn (12), a fuel supply line (L<sub>2</sub>) and one or more igniters (SP) for igniting the fuel. The apparatus (10) is equipped with an electrolytic unit (15) to produce fuel electrolytically and to use the fuel in the combustion chamber (11) in explosive combustion. The invention also concerns a method for acoustic cleaning. In the method, an acoustic cleaning apparatus (10) is equipped with an electrolytic unit (15), fuel is produced electrolytically in the electrolytic unit (15), the fuel is conducted along a fuel line (L<sub>2</sub>) to the combustion chamber (11) and igniters (SP) in the combustion chamber (11) are activated.

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## Apparatus and method for acoustic cleaning

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The invention concerns an apparatus and method for acoustic cleaning.

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Acoustic cleaning, which is also called acoustic chimney sweeping, is a method used e.g. for cleaning boilers, silos, cyclones, blowing fans, filtering apparatuses and other such. The acoustic cleaning method can be used in such places where e.g. powdery substances are treated or where e.g. soot or dust result as harmful by-products. Such particles easily form pile-ups, which will make the progress of the process difficult and will reduce its functionality.

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The possibility to operate without interrupting the process is an advantage of acoustic cleaning compared with various mechanical cleaning methods. Another noteworthy advantage is the method's ability to clean also fringe areas and other places, which are difficult to reach. The method does not wear and tear the objects to be cleaned, it is easy to use and its maintenance costs are low.

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In acoustic cleaning, the object to be cleaned is subjected to an acoustic wave (sound wave), which carries a pressure shock to the particles to be worked loose. In order to achieve a cleaning result, the force carried to each particle by the sound pressure impulse must exceed the force keeping the particles adhering to the base or keeping the particles adhering to each other.

Acoustic cleaning apparatuses are known e.g. from the publications WO-82/01328 and WO-82/03803.

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In an acoustic cleaning apparatus, the typical duration of the sound pressure impulse is a few seconds, and these impulses are supplied with intervals of 2-15 minutes. A

typical basic frequency of the sound is 20-360 Hz and the strength of the sound pressure level typically used is 130-200 dB.

5 To form a sound pressure impulse a method is known, wherein a fuel mixture is brought into a combustion chamber, and the mixture is burnt explosively. An arrangement of this kind is known from publication abstract SU-871186. In such arrangements safety risks occur, which result from the use of easily inflammable fuels in a hot power plant environment. In addition, the explosion impulse may break fuel tubing in the acoustic cleaning apparatus, which again will cause a risk of  
10 fire or explosion. Another problem is the relatively slow combustion in the long cylindrical combustion chamber.

The purpose of the present invention is to solve the problems occurring in state-of-the-art arrangements and to bring about a safer and more efficient apparatus and  
15 method for generating sound pressure impulses for acoustic cleaning.

The apparatus according to the present invention is characterised mainly in that the apparatus is equipped with an electrolytic unit to produce fuel electrolytically and to use the fuel in the combustion chamber in explosive combustion.  
20

The method according to the invention for its part is characterised in that the method comprises the steps of equipping an acoustic cleaning apparatus with an electrolytic unit, producing fuel electrolytically in the electrolytic unit, conducting the fuel along a fuel line to a combustion chamber, and activating igniters in the combustion  
25 chamber.

In the arrangement according to the present invention, fuel gases are used to generate a sound pressure impulse, which fuel gases are brought about electrolytically in connection with the acoustic cleaning apparatus by using water as  
30 the raw material and e.g. potassium hydroxide or some other inorganic salt as the electrolyte. With such an arrangement no separate fuel storage is needed, whereby

no problems will result from the storing of easily inflammable fuel gases. Hereby, pure water also results as the combustion result of the explosive combustion produced to bring about the sound pressure impulse, which is advantageous in environmental terms.

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In the following, the invention will be described in greater detail with reference to the appended drawing, which shows the functional diagram of the acoustic cleaning apparatus according to the invention.

10 The acoustic cleaning apparatus 10 includes a combustion chamber 11, an acoustic horn 12, a power source 13, a timer 14, an electrolytic unit 15 and a voltage source 16. Water is supplied along a line  $L_1$  to the electrolytic unit 15, which uses a suitable electrolyte, e.g. potassium hydroxide or some other inorganic salt, to bring about electrolysis. Separation of hydrogen from oxygen is achieved by the electrolytic unit  
15 15, when a voltage difference is connected between the positive and negative poles from the voltage source 16. The resulting combustion gas  $H_2$  is conducted to combustion chamber 11 through line  $L_2$ . The combustion chamber 11 is equipped with igniters SP, which are activated by the timer 14 to start an explosive combustion. There may be one or more igniters SP. When several igniters are used,  
20 preferably three or more, a more uniform combustion event is achieved. In the arrangement according to the invention, combustion is quick and complete, producing pure water as the combustion product.

In an advantageous embodiment of the invention, the combustion chamber 11 is  
25 equipped with a pressure sensor 17, which is used to monitor the state of combustion chamber 11 and to observe the combustion event occurring after a successful ignition.

After each successful ignition, the electric circuit of the electrolytic unit 15 is  
30 reactivated. Should triggering of the igniting spark fail to trigger a new combustion event, then the automatic safety system of the apparatus 10 will turn off the current

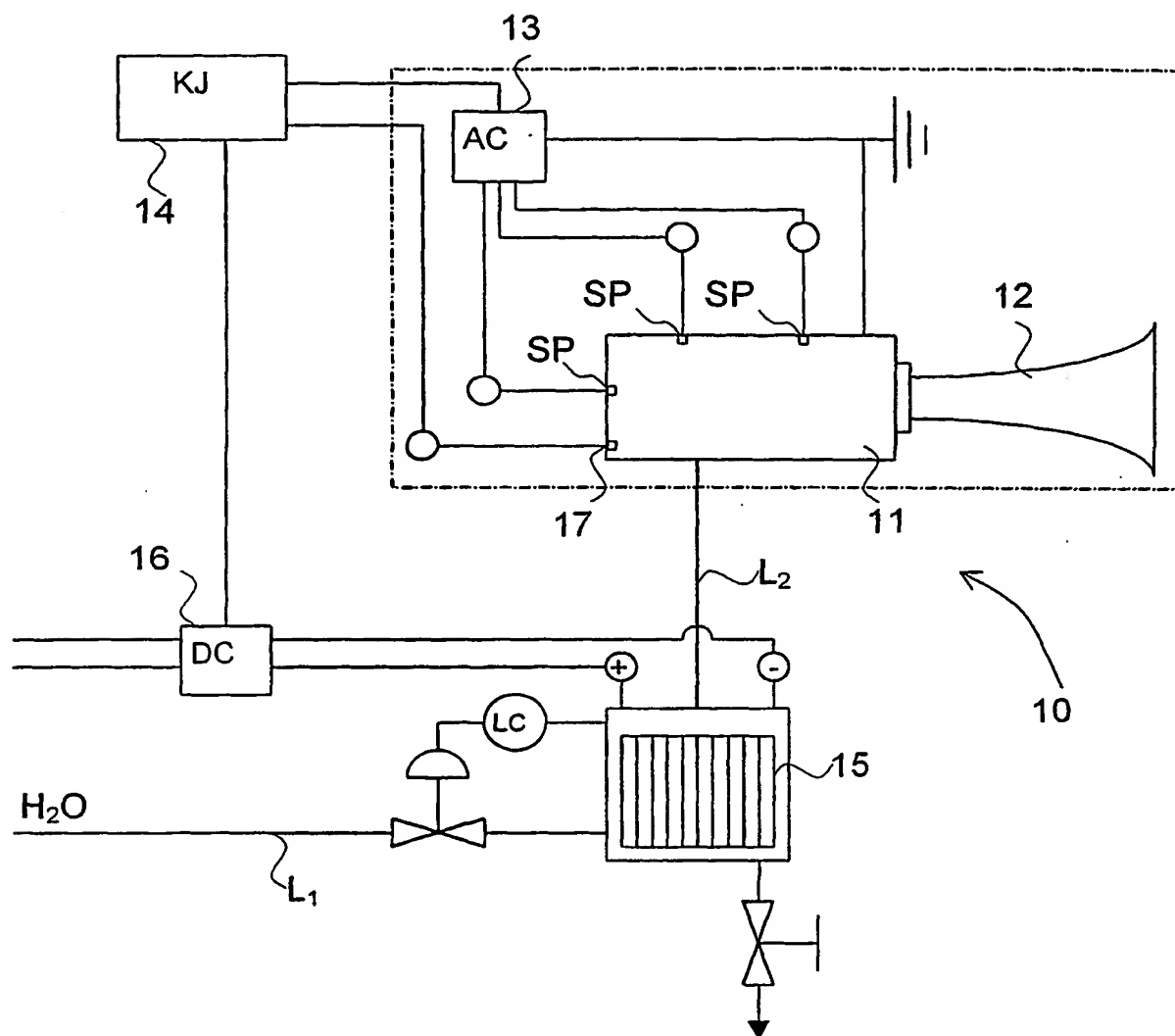
to the apparatus 10 and give an alarm announcement.

5 In addition, the acoustic cleaning apparatus according to the present invention may be equipped with safety automatics, which will prevent operation of the apparatus e.g. in a situation where there is not a normal operating temperature in the space to be cleaned. Any dust explosions in a cold space are hereby avoided.

In the following the patent claims are presented, to which the invention is not limited exclusively.

## Claims

1. Apparatus for acoustic cleaning, which apparatus (10) includes a combustion chamber (11), an acoustic horn (12), a fuel supply line ( $L_2$ ) and one or more igniters (SP) to ignite the fuel, **characterised** in that the apparatus (10) is equipped with an electrolytic unit (15) to produce fuel electrolytically and to use the fuel in the combustion chamber (11) in explosive combustion.
2. Apparatus as defined in claim 1, **characterised** in that the electrolytic unit (15) is adapted to produce fuel from water in the presence of an electrolyte.
3. Apparatus as defined in claim 1 or 2, **characterised** in that the electrolyte is potassium hydroxide or some other inorganic salt.
4. Method for acoustic cleaning, **characterised** in that the method comprises the steps of:
- equipping an acoustic cleaning apparatus (10) with an electrolytic unit (15),
  - producing fuel electrolytically in the electrolytic unit (15),
  - conducting the fuel along a fuel line ( $L_2$ ) to a combustion chamber (11), and
  - activating igniters (SP) in the combustion chamber (11).
5. Method as defined in Claim 4, **characterised** by activating the electrolytic unit (15) after a successful combustion.
6. Method as defined in Claim 4 or 5, **characterised** by equipping the apparatus (10) with safety automatics, which will prevent operation of the apparatus (10) when the object to be cleaned is not in normal use.
7. Method as defined in any one of Claims 4-6, **characterised** by noticing a successful explosive combustion event by a pressure sensor (17).



## INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI 01/00360

## A. CLASSIFICATION OF SUBJECT MATTER

IPC7: B08B 3/12

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: B08B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 9853926 A1 (KROGARS, U. ET AL), 3 December 1998 (03.12.98), figure 2, claims 1-13 --	1-7
A	EP 0053085 A1 (ETABLISSEMENTS SOMALOR-FERRARI "SOMAFER" S.A.), 2 June 1982 (02.06.82), figure 1, abstract --	1-7
A	US 5799624 A (W.-C. HSIEH), 1 Sept 1998 (01.09.98), figure 1, abstract -- -----	1-7

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

## \* Special categories of cited documents:

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "B" earlier application or patent but published on or after the international filing date
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- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "&" document member of the same patent family

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**INTERNATIONAL SEARCH REPORT**

Information on patent family members

02/07/01

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Patent document cited in search report			Publication date	Patent family member(s)		Publication date
WO	9853926	A1	03/12/98	AU	7531098 A	30/12/98
				FI	972252 A	29/11/98
-----						
EP	0053085	A1	02/06/82	SE	0053085 T3	
				AT	5023 T	15/10/83
				CA	1173335 A	28/08/84
				DE	3161192 D	00/00/00
				ES	507417 A	01/11/82
				ES	8300996 A	01/02/83
				FR	2494814 A	28/05/82
				GR	68327 A	30/11/81
				PT	74036 A,B	01/12/81
				US	4396434 A	02/08/83
-----						
US	5799624	A	01/09/98	NONE		
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